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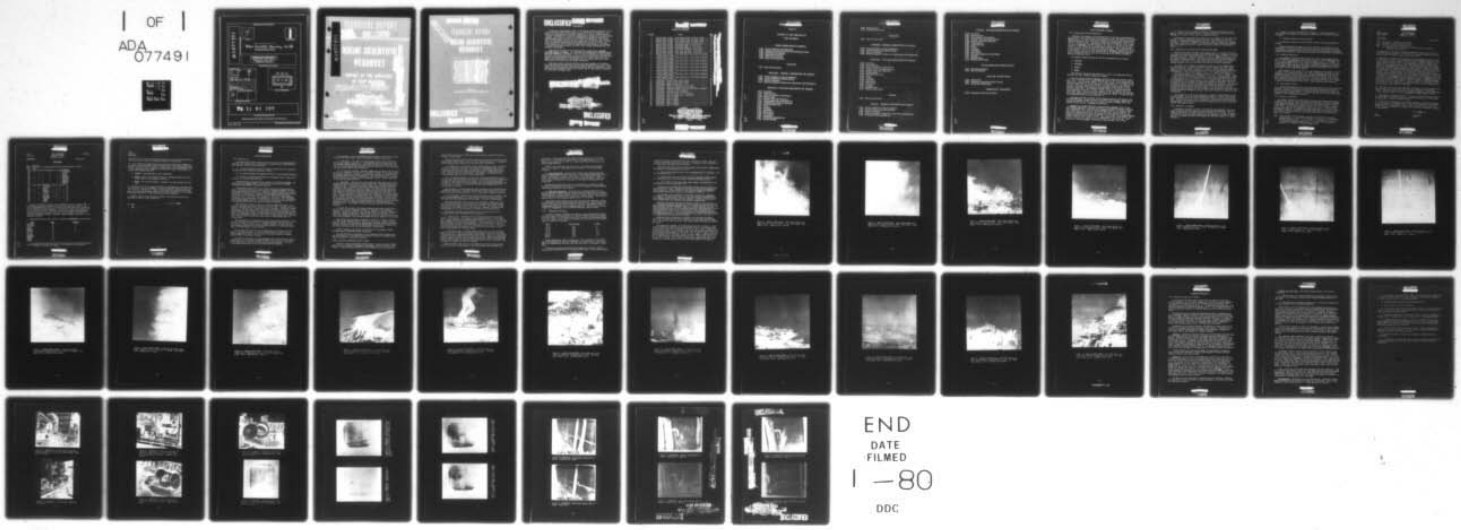

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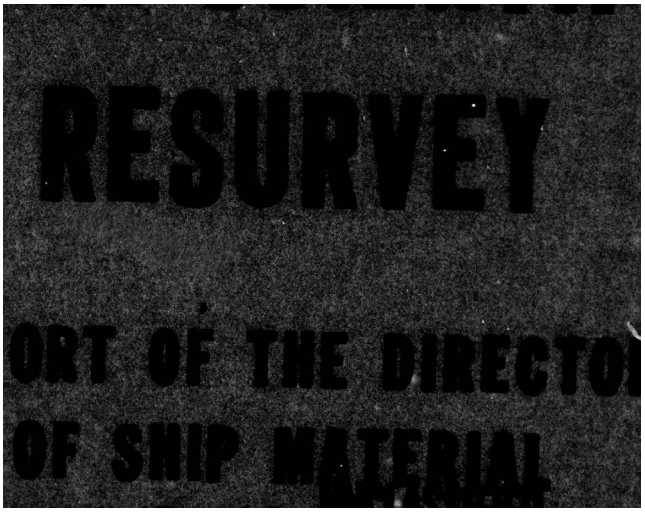
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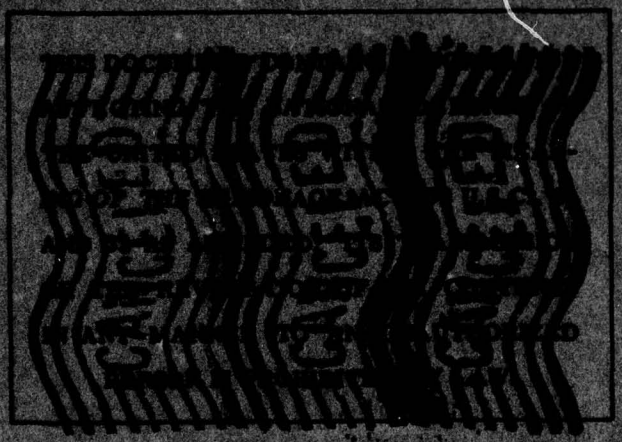
TECHNICAL REPORT

BIKINI SCIENTIFIC RESURVEY



Report of
THE DIRECTOR OF SHIP MATERIAL

Prepared for
The Project Officer
by the Technical Reports Section

Edited and Published by
[redacted]ed Forces Special Weapons Project
December 1947

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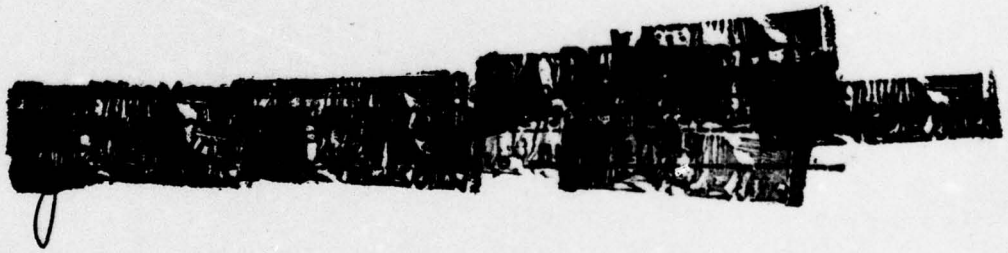
INTRODUCTION

Volume III of the Technical Report of the Bikini Scientific Resurvey is composed of Part IV of the overall report, and is devoted to the findings of the Director of Ship Material, Lieutenant Commander F. B. Ewing. Deep-diving operations were conducted from the decks of Coucal (ASR-8) throughout the period of the resurvey, in an effort to check upon and extend the findings of divers who inspected sunken target ships at the time of Operation Crossroads. Experimental work with underwater television was an integral part of this operation. In addition, an extensive shallow-water diving program was carried out in and about Bikini Lagoon as an aid to Scientific Groups which participated in the resurvey, to obtain certain data desired by the Navy, and to conduct experimentation with underwater photography.

Inspections were made of the following sunken target ships: Saratoga, Pilotfish, Apogon, and Nagato. A large number of photographs were made to supplement the inspections of the divers. Some of these photographs are incorporated in the body of the following report. Other pictures of less obvious value have been placed in the Annexes which accompany reports on the various ships, and the remainder have been preserved in an Appendix with the thought that some of them might reveal worth-while data upon expert examination.

Individual reports of divers similarly have been included in the Annexes, just about as they were taken down when the divers emerged from the water. Admittedly, they are not couched in well-rounded phrases, but they constitute the raw data upon which submarine reports must be based, and as such, should be preserved for the record in original form.



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SARATOGA: DETAILED DESCRIPTION OF DAMAGE

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DIVING OPERATIONS IN GENERAL

4.001 Diving Conditions and Inspections.

Throughout the resurvey, with the exception of a few days, diving conditions were ideal for both shallow-water diving from small boats, and deep-sea diving from Coucal (ASR-8). For about three days, roughness of the lagoon made shallow-water diving too hazardous, and on one day the swells were large enough to warrant cessation of deep-sea diving. Visibility was excellent; at depths of 210 ft. around the stern of Saratoga, it ranged between 15 ft. and 30 ft. Divers on the bottom, however, did have difficulty in seeing clearly because of fogs of sand and mud which were easily stirred up when the divers moved about. This latter difficulty caused losses in most of the bottom photographs of Saratoga. Radioactivity was of a low magnitude, and did not limit divers' time as it did immediately following Test B. Divers were able to have full diving time on the bottom, according to BuShips decompression tables.

The vessels inspected during the time of the resurvey were as follows:

A. Saratoga

B. Pilotfish

C. Apogon

D. Nagato

Very detailed inspections were made on A, B, and C, but sufficient time was available for only a cursory inspection of Nagato.

Much more serious damage to Saratoga occurred than had been reported originally. She is presumed to be beyond economical repair, even if she could have been kept afloat. The hull girder appears to have been twisted, and the flight deck is broken at about frame No. 192 and has about a 4-foot step in it. At frame No. 192 port and starboard, a crack was reported in each sheer strake as well as heavy buckling. The flight deck appears to bend up forward of the elevator, and the elevator is destroyed. Bottom damage included rupture of both starboard struts and misalignment of both No. 1 and No. 3 shafts as well as cracks in both starboard stern tubes. Forward from about frame No. 10 aft the garboard and B strakes were deeply indented as far as could be seen (frame No. 48-49). A crack was found in the starboard blister at about frame No. 76.

Pilotfish was found a complete loss with major failures in pressure and tank plating, scantlings, closures, piping, and miscellaneous fittings. Damage was so thorough throughout the boat that no one section or piece of damage can be considered the most serious. Pilotfish was destroyed.

Apogon was in considerable better condition than Pilotfish, and if it had been salvaged immediately, probably could have been put back in operable condition after considerable time. Main failures in Apogon occurred in the forward torpedo room, where there is a hole 18 in. by 30 in., in the top at about frame No. 30, another hole between main ballast tanks 6B and 6D, and a leak in the top of 6B. Because of passage of air from aft to forward, it is believed that bulkhead flappers, stuffing tubes or other fittings, failed. Vent risers to No. 1 main ballast tank and No. 7 failed at the valves, and it is presumed that others did also. Time required for salvaging Apogon is estimated as being between 3 and 4 weeks.

Not enough time was available to obtain any significant information about Nagato. She was capsized, and the No. 1 turret had fallen off the ship and was resting on the bottom. Shell plating was generally dented.

Precedence in diving inspections was set up in accordance with the priorities desired in BuShips memorandum, dated 28 May 1947, from Code 425 to Code 181. Recovery of instruments on Nagato was given very little consideration, in accordance with a letter from the Chief of the Bureau of Ordnance, Serial Re2c GKH/dmf: F141-6(19), dated 13 June 1947. Copies of these two letters are reproduced on pages 4 - 5.

4.002 Radioactivity in Diving Areas and Precautions Taken.

Before diving operations began aboard Coucal (ASR-8), all buoys to which the ship would be moored were thoroughly monitored and surveyed. Readings on the buoys ranged from two times background (gamma) to .1 r/24 hr. (gamma), and up to .6 r/24 hr. (beta and gamma). Personnel boarding the buoys to handle mooring lines wore protective clothing and gloves. They were checked for any possible contamination upon return to the ship. All mooring lines were monitored each time the ship changed moorings, with above procedure being used in the case of personnel.

All divers, while engaged in underwater examination of the target vessels, were equipped with a pencil dosimeter and three film badges; the latter being placed at the chest, abdomen, and leg of the diver. Upon reaching the surface after each dive, divers were washed down by hose before being hoisted aboard ship. All equipment -- shoes, suits, helmets, etc. -- were closely monitored daily. Readings obtained ranged from background (gamma) to 0.005 r/24 hr. (gamma), and from two times background (beta and gamma) to .1 r/24 hr. (beta and gamma). These readings were due to contamination by coral powder from the sunken ships and sand from the lagoon bottom. As a matter of fact, it was discovered that some of the diving equipment was contaminated prior to the resurvey, which can be attributed to the fact that this equipment was used during Operation Crossroads. The part of the ship from which the divers descended and ascended was checked for radioactivity at different periods during each day, and when diving was secured at the end of each day the entire area was thoroughly washed down and monitored. Periodic surveys were made throughout the ship on decks, lines and cable, winches and bitts, evaporators and heat exchangers, and any other gear or areas which might have been contaminated.

Upon completion of the diving operations, a complete survey was made of all diving equipment, lines, and other contaminated objects. All gear with readings above tolerances set by the Bureau of Ships was disposed of and cleared from the ship. The areas aboard ship that were subjected to contamination were washed down and monitored. All precautions were taken with regard to protection of personnel against radiological hazards.

4.003 Underwater Photography.

Underwater photography was used in all deep-sea investigations, and proved highly successful and very valuable in obtaining desired information. Lack of technical information concerning underwater lighting, depth of field, and proper lens aperture and shutter speed caused many poor exposures to be made. However, a variety of successful pictures were obtained, and these are deemed to be highly important.

In addition to deep-sea underwater photography, a considerable amount of shallow-water photographic work was done in assisting various Scientific Groups to obtain:

A. Permanent records of their operations.

B. Desired information of various types of marine life being studied and analyzed.

Further underwater photographic activity included a considerable amount of experimentation at various depths with varying lens openings and shutter speeds. Considerable new information in all fields of underwater photography was obtained through these experiments, and proved very valuable in the deep-water investigations.

4.004 Underwater Television.

An experimental television unit was set up and used aboard Coucal (ASR-8) with such targets as Saratoga's flight deck (over 100 ft. deep), Pilotfish (about 185 ft. deep), Apogon (about 175 ft. deep) and Nagato (about 200 ft. deep). It is believed that this was the first attempt to use this equipment at such depths. Natural light images obtained on the decks of Saratoga and Apogon were excellent, but attempted views of Pilotfish and Nagato were not successful because of the mud clouds off the bottom of the lagoon.

The equipment in its present form is very cumbersome and unwieldy for divers to handle. It is believed, however, that further development and study of the equipment for its use in ship-bottom and sound-gear examinations could probably save many dockings. Further employment could be found in salvage work, and in marine studies of harbor and ocean bottoms. Artificial lighting, at the present time, offers the same difficulties as in the case of divers' visibility. Clarity of images obtained appeared to equal divers' vision under similar conditions.

4.005 Shallow-Water Diving.

A shallow diving group was set up and operated throughout the Bikini Scientific Resurvey. The work of this group consisted principally of assisting numerous Scientific Groups of the resurvey in obtaining data and specimens for study from various sections of Bikini Lagoon. It further operated with the underwater camera equipment in the photographic experiments.

4.006 Results of Operations.

The results derived from diving operations during the resurvey were numerous. Perhaps the most valuable result involved the new information obtained on damage to Saratoga and Pilotfish, which were among the three vessels closest to Test B target center. The information contained in Section 4.001 is taken up in detail in this report for each ship inspected. Further, all divers' written reports containing information as to damage and diving conditions, are included along with photographic evidences. Underwater photographic experiments carried on proved their value by way of resulting in better photographs even before operations at Bikini were concluded.

NOTE: 4.007 through 4.030 and Figures 1 through 9 are included in separate Saratoga Annex. 4.031 to 4.051 and Figures 10 through 18 are included in separate Pilotfish Annex. 4.052 through 4.072 and Figures 19 through 25 are included in separate Apogon annex. 4.073 and 4.074 and Figures 19 through 25 are included in separate Nagato Annex.

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F141-6 (19)

NAVY DEPARTMENT
BUREAU OF ORDNANCE
Washington 25, D. C.

CONFIDENTIAL

13 June 1947

From: The Chief of the Bureau of Ordnance
To: The Chief of Naval Operations (Op-36)
Subj: Scientific Resurvey of Bikini Atoll.
Ref: (a) CNO rest ltr Op-36 B/cmf Ser 176P36, File All, to multiple addressees dtd 2 June 47.

1. Reference (a) states that a scientific resurvey of Bikini Atoll will be undertaken during the summer of 1947 in order to complete studies and projects begun in 1946 in connection with Operation Crossroads.

2. The Bureau of Ordnance Instrumentation Group has completed its work in connection with the operation and has submitted to the Technical Director a total of approximately thirty reports as well as results on radiant energy, low frequency sound, and surface waves. After Baker day, recovery operations were carried on with unabated vigor and very considerable success, so that perhaps 80% of the instruments were recovered. A party was left at Bikini for several weeks after the main groups had departed in an attempt to complete the recovery of the underwater instruments which had been attached to the so-called vertical stations. Some of these nearest the bomb had been completely buried in the bottom material which had settled over them and are by now corroded so that their readings would be useless and the free piston gages, of which there is still one, for example, on the Saratoga, are water soaked so that the chalked paper used in recording the stylus mark is probably completely missing. On Nagato in the crew space, port side, main deck, frame 16, there is installed a spring chronograph which might contain a valid record on a magnetic tape. It is believed, however, that recovery of this instrument would not add materially to the information at hand concerning the air blast in shot Baker.

3. Since the total value of the remaining instruments is trifling compared with the cost even of recovering them, and since the information to be gained is first, of doubtful validity and second, negligible compared with the large amount of data already on hand, it is not recommended to attempt further recovery.

4. With regard to Ordnance Equipment it is felt that nothing worth while would be accomplished by attempting salvage of components such as fire control radar antennas, guns or armor from sunken vessels.

5. In view of the foregoing and of the acute shortage of scientific personnel, it is the opinion of this Bureau that it would not be fruitful to send Ordnance representatives to the resurvey of Bikini Atoll. By copy of this letter the Bureau of Ships is requested to represent the interests of the Bureau of Ordnance at the resurvey.

G. F. HUSSEY, Jr.

K. H. Noble
Acting

CC:
BuShips

COPY
Code 425

NAVY DEPARTMENT
BUREAU OF SHIPS
Washington 25, D. C.

JMW/amb

RESTRICTED

28 May 1947

MEMORANDUM

To: Code 181
Subj: Examination of Sunken Target Vessels During Resurvey of Bikini
Encl: (S.C.)

(A) Report of Divers Examinations of USS SARATOGA.
(B) " " " " " " PILOTFISH.
(C) " " " " " " APOGON.
(D) " " " " " " NAGATO.
(E) " " " " " " ARKANSAS
(F) " " " " " " GILLIAM
(G) " " " " " " CARLISLE
(H) " " " " " " ANDERSON
(I) " " " " " " LAMSON
(J) Final Report SARATOGA - Test B - Copy No. 10
(K) " " PILOTFISH - " " - " " 10
(L) " " APOGON - " " - " " 10
(M) " " NAGATO - " " - " " 10
(N) " " ARKANSAS - " " - " " 10
(O) " " YO 160 - " " - " " 10
(P) " " GILLIAM - " A - " " 10
(Q) " " CARLISLE - " " - " " 10
(R) " " ANDERSON - " " - " " 10
(S) " " LAMSON - " " - " " 10
(T) " " SAKAWA - " " - " " 10

1. During the resurvey of Bikini Lagoon scheduled for July - August, 1947, it is desired to obtain such additional information concerning certain of the sunken CROSSROADS target vessels as will be practicable within the limitations of the facilities and time available. The services of USS Coucal (ASR8) are to be utilized for this work. Sufficient divers and equipment (including underwater photographic and lighting equipment, extra moorings, and portable recompression chambers) should be obtained to assure maximum utilization of time available at Bikini.

2. The ships which were sunk incident to Operation CROSSROADS are listed below.

SHIP	TEST	PRIORITY
SARATOGA	B	1
PILOTFISH	B	2
APOGON	B	3
NAGATO	B	4
ARKANSAS	B	7
YO 160	B	6
GILLIAM	A	
CARLISLE	A	
ANDERSON	A	
LAMSON	A	
SAKAWA	A	

It is desired that principal efforts be directed towards securing additional data on Saratoga, Pilotfish, and Apogon. It is realized that conditions

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encountered in the field may necessitate departure from the desired priorities, which are listed to assist in planning of work of the diving unit.

3. In all examinations attention should be directed towards major changes in the shape of the hull girder, tears in and distortion of structural plating and members, failures in way of rivetted or welded connections, and failures in way of shell openings such as condenser sea connections. Items of particular interest aboard certain ships are:

a. SARATOGA. Starboard side of hull; flight deck.

b. NAGATO. Area in way of the war damage to determine whether this was a primary factor in the sinking of the ship.

c. SAKAWA. The nature and extent of damage to the shell plating near the stern.

4. Enclosures (A) to (T) inclusive represent the available data concerning the sunken vessels. They are forwarded to provide background information which will be of use to the diving unit. Study of these data will indicate the principal gaps in the existing knowledge concerning the sunken ships and will also prevent unnecessary duplication of work which has been done previously.

5. Complete reports of the information gained by the diving unit should be submitted to Bureau of Ships (Code 425).

/s/ J. M. WATERS

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SHALLOW WATER DIVING

4.075. Organization.

The Shallow-water Diving Group was set up as part of the Bikini Scientific Resurvey, and operated under the supervision of the Director of Ship Material. The objective of the unit was three-fold:

A. To assist the various Scientific Groups connected with the resurvey in carrying out their scheduled operations at Bikini.

B. To provide underwater photographic service for those groups desiring it.

C. To carry out experimental underwater photography, and to obtain necessary data for future use by the Navy.

The Shallow-water Diving Group was composed of one Officer-in-Charge, one master diver from Coucal (ASR-8), and six second class divers from EODU, Indianhead Powder Factory, Indianhead, Maryland.

A Radiological Safety Officer was present during all diving operations. Divers' clothes were monitored, as were anchors, descending weights, and specimens brought aboard the diving boat. Generally speaking, there was no special problem due to radioactivity, although coral specimens from coral heads off the reef about 1/2 mile from the north tip of Bikini Island exhibited average activity of .02 - .03 r/24 hr, and a maximum of .06 r/24 hr. These specimens were placed on the after deck of the diving boat and later in the contamination center aboard Chilton (APA-38). The after deck of the diving boat was washed down subsequently, and no activity above background remained.

When available, an LCM was used as the shallow-water diving boat. As a substitute when the LCM was not available, either an LCVP or an LCPL was put in service. The LCM was the preferred-type boat of the three. Sufficient room was available in the well deck to set up the diving equipment, and, because it had twin engines, the boat proved more maneuverable for anchoring than did the other types. On windy days, however, the high freeboard and ramp of the LCM made operations more difficult, because of the amount of surface subjected to wind pressure. The wide tank tops and after deck, however, offered ample space for tending divers.

The LCVP type boat, although smaller than an LCM, provided sufficient space for the diving gear in the well deck. Tending the divers over the side was difficult, on the other hand, due to the narrow stringer. The LCPL type boat was extremely crowded with the diving equipment aboard, but tending was easier than on the LCVP because of the low sides.

On all three type boats (since the compressors were located in the well deck) it was found necessary to connect flexible copper hose from the compressor exhaust and lead it over the side to preclude any danger of exhaust fumes entering the compressor intakes.

The Danforth-type anchor was used throughout diving operations, but was not satisfactory due to operating constantly around coral. Anchors fouled readily in the jagged coral, and bent or broke when being hoisted aboard. It is believed that mushroom-type anchors would have been more desirable.

The remainder of the diving equipment used throughout shallow-water diving operations is listed below, along with comments concerning performance:

A. Compressors. Two types of approved shallow-water diving compressors were used to supply diving air: (a) the DeVibliss gasoline-driven type, and (b) the DAPCO gasoline-driven type. Both types proved to be inferior for the type of work performed during the Bikini Scientific Resurvey, or any other long, continuous shallow-water diving operation.

B. Air hose and lifelines. Standard oxygen hose was used to furnish diving air from the compressor to the diver. The 50-foot lengths of hose were coupled by standard oxygen hose couplings. Each mask had 3 lengths providing 150-foot air supplies between divers and compressors. The hose was married to 21-thread manila lifeline with standard marrying wrappings of marlin. Daily inspections of hose and couplings were made.

C. Face Masks. Several types of face masks were used, and found to have varying efficiency in this type of shallow-water work. The masks available included four each of the Jack Brown and Tico types, and 2 of the Mk 3 gas mask (converted) type. In addition, four self-contained shallow-water units were available at the request of Scientific Groups. The self-contained units, however, were not used because the groups originally requesting them agreed that face masks with topside air supply were more satisfactory for the work to be done. The Tico type mask was found to have poor visibility, and the hard rubber form of the mask proved very uncomfortable, due to difficulty in fitting divers' faces. The Mk 3 gas mask (converted) proved very comfortable on divers' faces, but vision was distorted due to the curved lenses of the mask. The Jack Brown type with topside air supply was generally used for diving operations, and proved satisfactory both in fitting the divers' faces and in allowing maximum undistorted vision. The Schreder non-return valve was used with the Jack Brown type mask.

D. Belts and clothing. The standard shallow-water quick release diving belt of 30 lb. was used throughout operations. Every diver was completely clothed as a protection against coral cuts and ingestion of harmful radioactive particles. Garments consisted of Army Air Force summer flying suits, field shoes, and leather-palmed gloves. The flying suit proved very satisfactory from a protection standpoint, and allowed necessary freedom of movement on the bottom.

Under water camera equipment consisted of the Robot II camera, installed in either the Mk 2 pressure case or the Mk 7 pressure case. The Mk 2 pressure case was used for all shallow-water photography, the divers actually taking the pictures. The Mk 7 was used by the shallow-water diving unit for depths up to 150 ft. with no divers down, and for photography of sunken ships.

The Mk 2 pressure case mounted on the Woods Hole Oceanographic camera frame was used for underwater flash photography.

The main difficulty encountered with the underwater camera equipment was that the weakening of the transportation spring in the Robot II camera often caused the camera to transpose incorrectly.

4.076 Operations Assisting Scientific Groups

The Shallow-water Diving Group operated daily to assist Scientific Groups, and to carry on underwater experimental photography. About three days of bad weather, occasional material failure of diving equipment and the diving boat,

and the need of the boat for other work of the resurvey, curtailed diving operations to some extent.

Specific Scientific Groups connected with the resurvey were assisted by the Shallow-water Diving Group to carry out their required field work. A listing of groups assisted and an indication of the work done is as follows:

A. Radiobiology. In accordance with a schedule drawn up prior to arrival at Bikini, the Radiobiology Group, was assisted by the Shallow-water Diving Group once a week for five weeks. The purpose of these diving operations was to lay rotenone poison over selected coral heads, and to collect the various forms of marine life that were poisoned. Both members of the Radiobiology Group and Navy divers took part in these operations.

The coral heads selected were as follows: three large heads off the reef between Bikini and Amen Islands; one head off the eastern end of Enyu Island; and one head off the western end of Arji Island. Four of these operations were successful. The operation off Arji, however, was only partially successful, due to a strong bottom current which caused the poison and poisoned fish to be carried away too quickly.

The specimens collected augumented those available in the inter-tidal zone in studies of radiation. Information derived from these studies is also to be used by the Atomic Energy Commission in the overall study of radiation effects.

B. Geology group. The Geology Group was assisted on three occasions. The first trip was unsuccessful; no diving operations could be carried out due to sea conditions that proved unsafe for personnel. This was off Erik Island.

The second and third trips, however, were successful. These were on an isolated coral head about one mile north of the western end of Prayer Island. The structure and manner of coral head growth off Prayer Island were studied, and sand and coral samples found in the area were collected. The diving unit photographed various coral structures as requested by the Geology Group.

Information obtained in these operations is for the use of the U. S. Geological Survey and the Naval Electronics Laboratory.

C. Biology group. The Shallow-water Diving Group assisted the Biology group on two occasions. The purpose of these operations was to collect data, and to obtain specimens for the Smithsonian Institute, the Division of Fish and Game of Hawaii, and the University of Hawaii. The data in question was concerned with food habits, and with the disappearance or non-disappearance of certain species around coral heads. The first operation was on the reef on the lagoon side of Erik Island; the second was on an isolated coral head about one mile north of the western end of Prayer Island.

D. Plant physiology. The Shallow-water Diving Group assisted the Plant Physiology Group in obtaining specimens and information along the reef running from the east end of Enyu Island around to Amen Island. Specimens of algae were collected from coral heads along the reefs and off the islands for physiological study of radiation effects, and for taxonomic purposes. Observations were made of the growth of algae on both radioactive and non-radioactive coral heads, and underwater photographs were made as requested.

Special attention was paid to a coral head about 1/2-mile along the reef from the north end of Bikini Island. The head was dead, but the algae were

still alive. It was known that the surge from Test B passed over this head. The pieces of coral retrieved exhibited gross beta-gamma counts of .02 - .03 r/24 hr, and a maximum of .06 r/24 hr. Radiological safety measures were enforced during operations.

Several other operations were carried out by the Shallow-water Diving Group at the request of other members of the resurvey. The following were included:

A. Giant Tridachnids. During several shallow-water diving operations, large tridachnids were secured by the group. These large mollusks were found on isolated coral heads, one about one mile north of the western end of Erik Island. The clams were secured by the divers forcing the clams to close, and then securing 21-thread line around them for subsequent hoisting aboard the diving boat.

Tridachnids obtained were placed in a refrigerator, to be sent to Yale University for dissection and study, or dissected by biologists for physiological study during the period of the resurvey.

B. Radioactive specimens. As directed by the Technical Director, the Shallow-water Diving Group obtained desired radioactive specimens for the Atomic Energy Commission. These consisted of pieces of coral found in 25 ft. of water off the reef about 1/2 mile from the north tip of Bikini Island. The gross beta-gamma activity of these specimens ranged from .03 - 0.6 r/24 hr.

Radiological safety measures were enforced during this operation. Divers were monitored, and no radiation hazard was found to exist. The specimens were placed on the after deck of the diving boat, and then, transferred to the decontamination center upon return to Chilton (APA-38). The deck of the boat was washed down subsequently, and no radiation hazard was found to remain.

4.077 Underwater Photography.

In order to expedite underwater photography on the sunken ships at Bikini, the Shallow-water Diving Group made test runs in different parts of the lagoon at various depths. At each depth various shutter speeds and diaphragm openings were used. Results and corresponding readings were correlated in the following table of satisfactory exposures:

Depth	Shutter Speed	F. Stop
25 ft.	1/50	11
40 ft.	1/50	8
55 ft.	1/50	8
65 ft.	1/50	8
75 ft.	1/50	6.3
100 ft.	1/25	5.6
150 ft.	1/25	4

These readings were used as a base table for the remainder of the experimental photography work, and for photography of the sunken ships. They may or may not be satisfactory for water other than that found in the Marshall Islands area.

Additional experimental underwater photography was carried on when the Shallow-water Diving Group was not assisting other groups. Divers aiming cameras

on definite subjects accomplished this work. As much as possible, days were chosen in accordance with desired conditions of sunlight, clouds, and water in the areas where experiments were to be made.

Test shots were taken of the following objects in the course of experimental photography, at various depths up to 140 ft.

A. Around coral heads with very little suspended matter in the water; visibility was about 60 ft.

B. Around coral heads near reefs, where mild turbulence caused slightly more suspended matter to be in the water; visibility was about 20 ft.

C. At the edge of reefs where heavy surge caused a concentration of suspended matter; visibility was about 6 ft.

It was found that Eastman Plus X film gave the best results at all depths when using natural light. Eastman Super XX gave an excellent performance in natural light up to depths of 100 ft. When flash photography was employed, Eastman Super XX gave good results at all depths up to 180 ft.

Also observed were the effects of above-water conditions on underwater photography. In shallow-water work, a clear day with white scattered clouds and a moderate sea was found to be best. However, overcast and hazy days did not noticeably affect the underwater photography of sunken ships.

Excellent photographs were taken at depths of 180 ft. to 210 ft. in natural light with hydrophotometer readings of 90. It is noted that this tends to disagree with the following statement in Bureau of Ordnance Pamphlet No. 1542: "A hydrophotometer reading of 90 in sparkling clear water limits the depth of sunlight photography to about 60 ft." The reason for this discrepancy was not determined at this time. It is every probable that the extremely clear water and reflecting qualities of the bottom peculiar to the Bikini area may have had a favorable effect upon the results obtained.

Underwater flash photography was carried on for the Naval Electronics Laboratory in connection with their dredging for bottom samples in the target area. The work was done from an LCI, and covered areas both inside and outside the lagoon.

Photography was attempted at depths varying from 50 ft. to 600 ft. Satisfactory results were obtained only at depths up to 180 ft. The attempts made at depths over 180 ft. were unsuccessful, as the LCI was forced to maintain constant headway because of strong winds, heavy seas, and navigational hazards, and the Woods Hole frame streamed too far astern. All attempts to take pictures at depths exceeding 180 ft. were made outside of Bikini lagoon. Super XX film and No. 5 flash bulbs were used during these operations. Above-water weather conditions had no effect on the results, because flash equipment was used. Best results were obtained using a lens stop of F.8 and a speed of 1/50 second.

Figure 1. SHALLOW WATER DIVING. Reef between Bikini and Amen, about 2 mi. west of Bikini. Stop: F11, Speed: 1/50, Depth: 55 ft. ABCR Photo No. 6001-18.

Figure 2. SHALLOW WATER DIVING. Reef between Bikini and Amen, about 2 mi. west of Bikini. Stop: F5.6, Speed: 1/50, Depth: 55 ft. ABCR Photo No. 6001-19.

Figure 3. SHALLOW WATER DIVING. Reef between Bikini and Amen, about 2 mi. west of Bikini. Stop: F5.6, Speed: 1/50, Depth: 75 ft. ABCR Photo No. 6001-24.

Figure 4. SHALLOW WATER DIVING. Reef between Bikini and Amen, about 2 mi. west of Bikini. Stop: F5.6, Speed: 1/50, Depth: 75 ft. ABCR Photo No. 6001-23.

Figure 5. SHALLOW WATER DIVING. Descending weight in silty water, visibility about 6 ft. Stop: F8, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6050-1.

Figure 6. SHALLOW WATER DIVING. Descending weight in silty water, visibility about 6 ft. Stop: F5.6, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6050-2.

Figure 7. SHALLOW WATER DIVING. Descending weight in silty water visibility about 6 ft. Stop: F3.5, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6050-3.

Figure 8. SHALLOW WATER DIVING. Coral head off Rokar, silty water, visibility about 6 ft. Stop: F4, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6038-6.

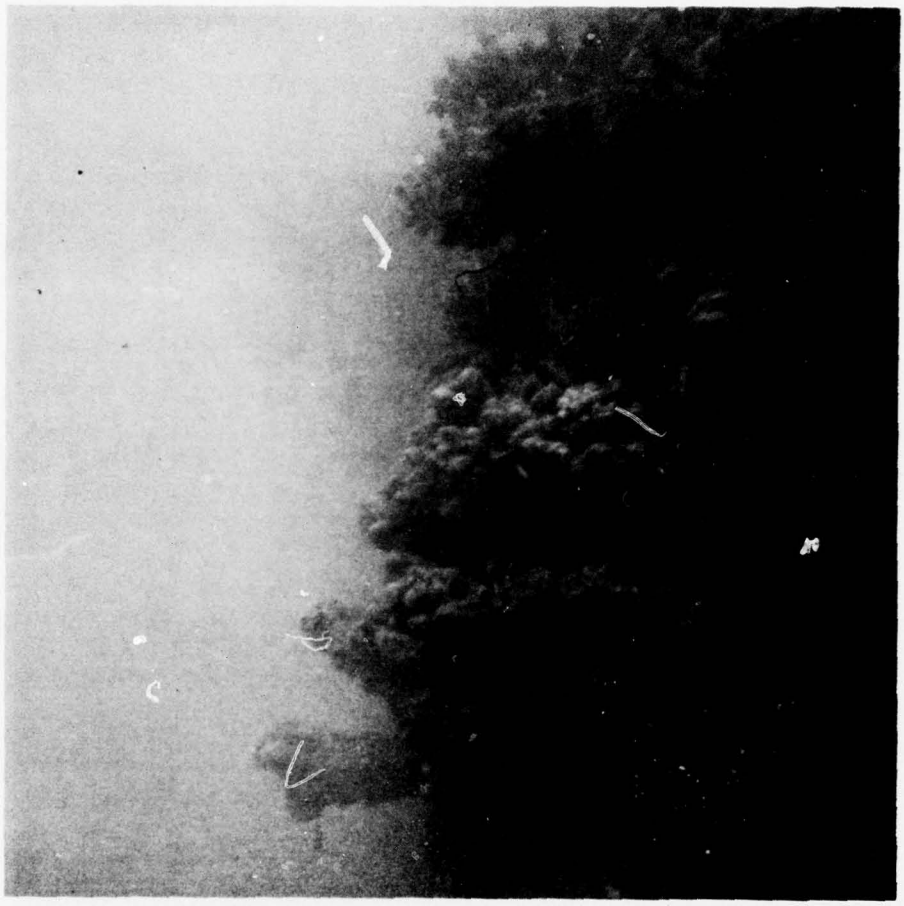

Figure 9. SHALLOW WATER DIVING. Coral head off Rokar, silty water, visibility about 6 ft. Stop: F4, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6038-3.

Figure 10. SHALLOW WATER DIVING. Coral head off Rokar, silty water, visibility about 6 ft. Stop: F4, Speed: 1/50, Depth: 30 ft. ABCR Photo No. 6038-1.

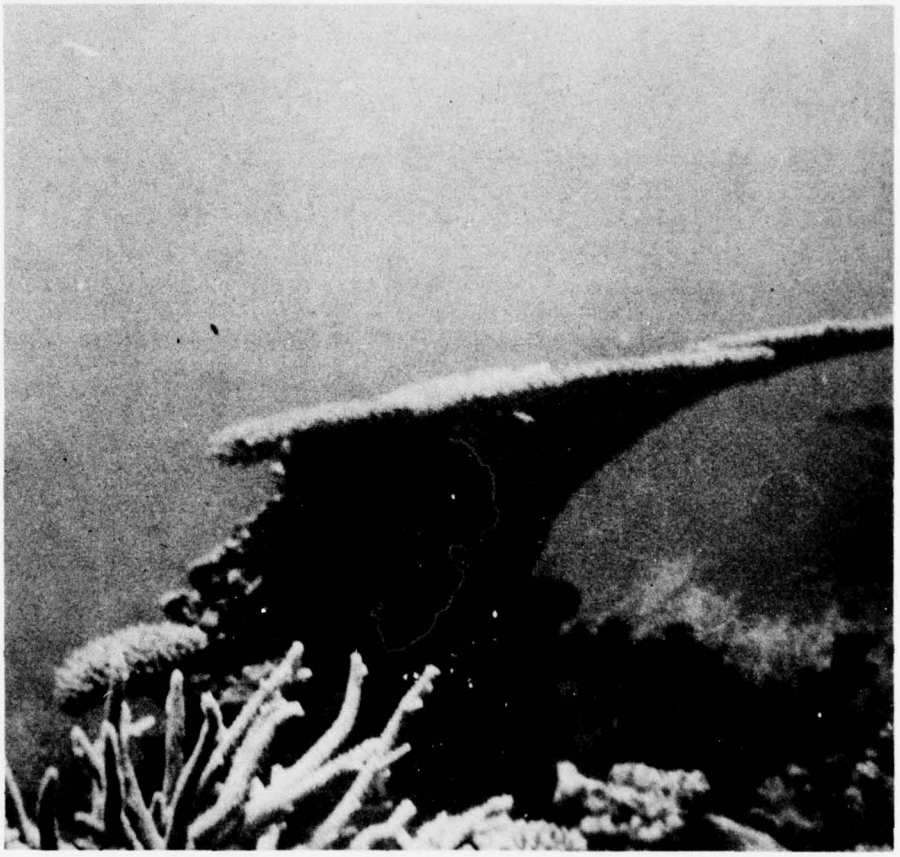

Figure 11. SHALLOW WATER DIVING. Coral head about 1 mi north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6034-10.

Figure 12. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1.50, Depth: 40 ft. ABCR Photo No. 6034-9.

Figure 13. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6034-7.

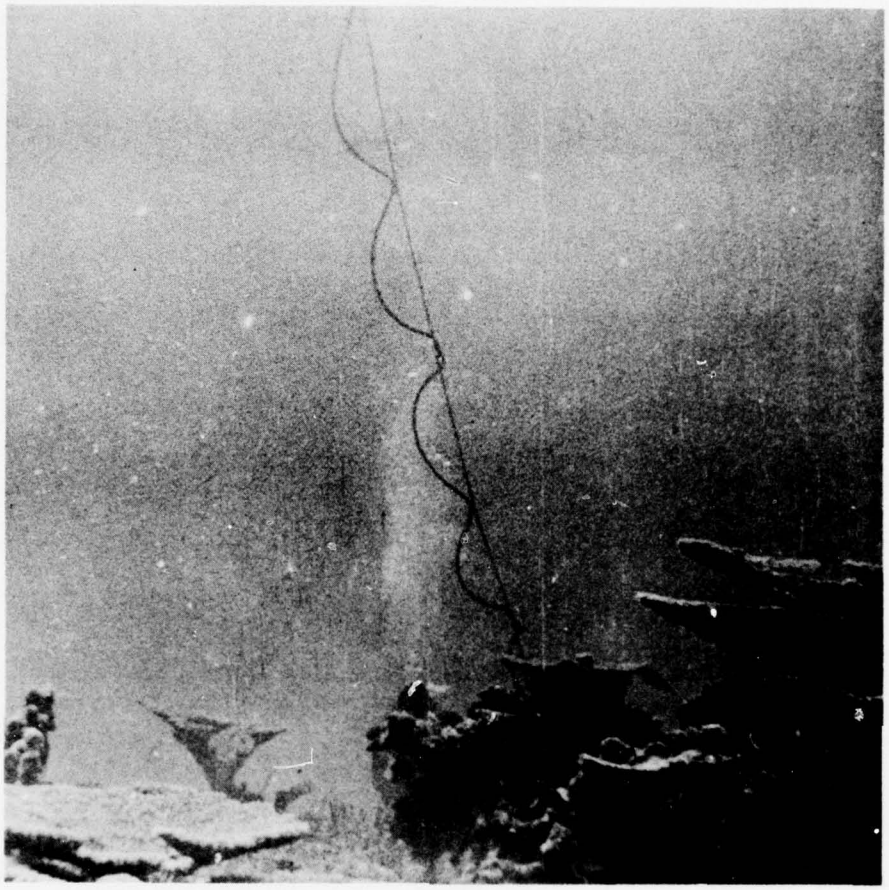

Figure 14. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6020-4.

Figure 15. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6020-3.

Figure 16. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6020-2.

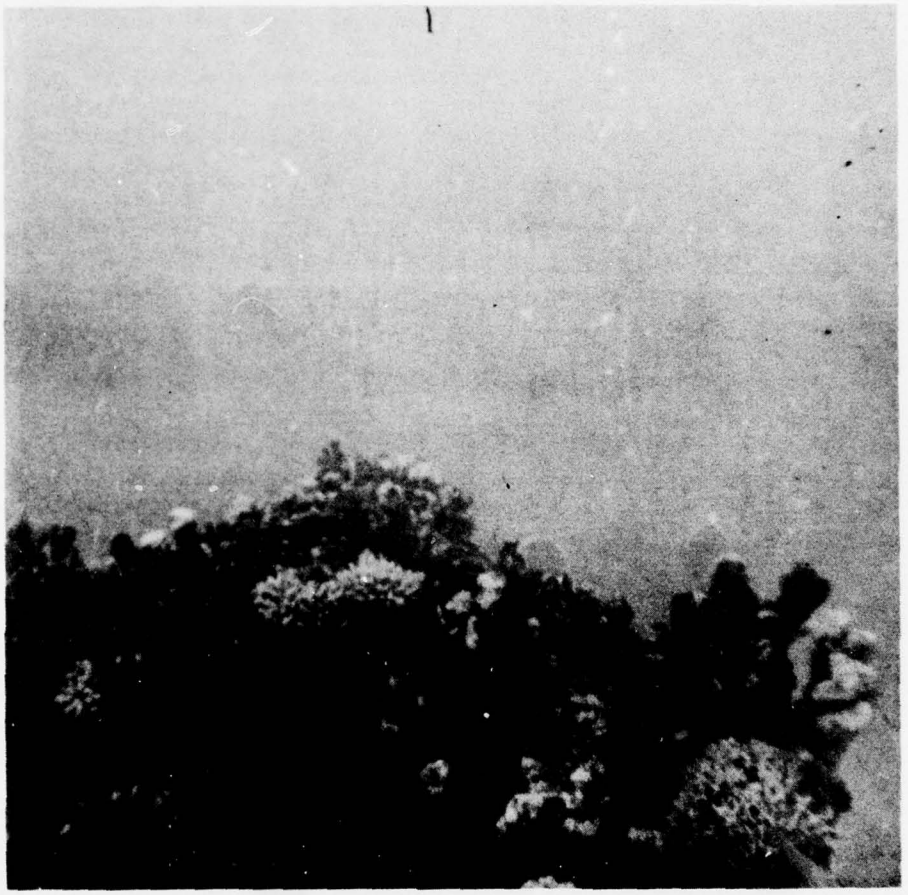

Figure 17. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6034-14.

Figure 18. SHALLOW WATER DIVING. Coral head about 1 mi. north of western end of Prayer Island. Stop: F8, Speed: 1/50, Depth: 40 ft. ABCR Photo No. 6034-12.

UNDERWATER TELEVISION

4.078 Underwater Television at Bikini

In accordance with Navy contract NOB 111-202, as amended, Cornell Aeronautical Laboratory, the contractor, engaged in a project to develop equipment for application of television as an aid to underwater investigations. The objective of the project was two-fold: (a) to determine the feasibility of the proposed application of television methods, and (b) to aid diving operations in connection with the inspection of vessels sunk as a result of Test B at Bikini Lagoon.

The following report is based upon experimental tests of underwater television equipment conducted during the course of the Bikini Scientific Resurvey. Results of these tests have not been fully evaluated, and will not be until they have been weighed by laboratory engineers and naval technicians. For example, it might be inferred from results of tests made that a feasible development approach could be in the direction of suspending camera units, independent of divers, with complete remote control, including that of movement.

Subsequent to such further evaluation and analysis, a final report will be submitted in accordance with the provisions of the contract. This report will include more specific presentation of results and conclusions, together with development details, photographs and schematic diagrams.

Equipment. Inasmuch as available funds and a limited design and development period of approximately five weeks did not permit any basic development of specific television equipment, existing standard naval airborne equipment, Model ATK/ARK, was selected for adaptation. Two camera units were modified for electrical remote control. Watertight camera casings were constructed with camera windows and necessary fittings for power and control cable leads. These were designed to permit the submerging of camera units, and were capable of withstanding water pressure at depths in excess of 200 ft. Diving lamps fitted with remote power control were attached to the camera cases to provide required illumination.

A remote control panel unit was designed and constructed to contain all remote controls and associated circuits, power supplies, batteries, battery-charging resistors, and power switches.

Operations. Upon completion of assembly and construction as outlined in the preceding paragraphs, and following laboratory tests, operational tests were conducted in the mine test tank at the Naval Ordnance Laboratory, Washington, D. C. The results indicated satisfactory performance, and the equipment was shipped immediately to the project area at Bikini Atoll, for installation on Coucal (ASR-8). During the conduct of diving operations from this vessel, the television equipment was used on six different days for viewing various subjects aboard four sunken target vessels: the aircraft carrier Saratoga, the submarines Apogon and Pilotfish, and the ex-Japanese battleship Nagato. Conclusive operational tests were accomplished under varied conditions of illumination, and from camera positions on the bottom, on decks or surfaces of the sunken vessels, and suspended above the subject targets.

The operations were witnessed by qualified technical observers. Numerous still and motion pictures were made of images appearing on the television screen for subsequent evaluation.

Results and conclusions. The results obtained support the following conclusions:

A. The application of television technique to underwater inspection and investigation is technically feasible and is considered highly desirable for many uses.

B. The adaptation of existing equipment did not constitute a material aid to diving operations during the Bikini resurvey.

With respect to B, it was demonstrated that underwater television, as a useful tool for divers, will require specific equipment design and development, and probably further investigation of illumination techniques. Moreover, existing camera equipment in its present form is too ponderous for underwater inspections. This results from the necessity of housing a complete 18-tube camera conversion unit, with adequate shock mounting, in a pressure-resisting container of adequate dimensions. Divers experienced considerable difficulty in moving these units about underwater, due to water resistance on, and inertia of the equipment, and the fact that their own movements are very restricted. Cable weight also was too high, and dragging for any distance posed an additional problem.

The tests also proved the futility of attempting to view an object largely obscured by a heavy suspension of particles or foreign matter in the surrounding water. Tests from camera positions on the bottom of the lagoon where a heavy suspension of silt was stirred up by divers' movements produced only negative results.

When operation under reasonably clear-water conditions was possible, it was found that the light of the sun was entirely adequate illumination at depths up to 185 ft, as proven by tests on the submarine Apogon. During these tests good images were obtained at 0800 and 1830, when the sky overhead showed illumination of less than one-tenth that provided by the sun overhead at noon. A light overcast, providing diffused light, was found to be excellent for underwater work. During tests on the flight deck of the carrier Saratoga, at about 100 ft. depth, the image from one camera actually suffered from over-illumination.

According to divers' reports, clarity and detail of the television image was approximately equal to their visual perception underwater. Fish swimming through the field of view could be identified readily as to species. The best overall views were obtained when the cameras were suspended some 20 ft, to 30 ft. above the flight deck of Saratoga. Contrast of underwater scenes in general was not great, being about equal to visual contrast underwater in all images observed. It also was evident that cameras fitted with wide-angle lenses would be advantageous in underwater work, where most inspections would be made at fairly close range. Lenses used covered a field of 24°, permitting a view of only an 8-foot square at a distance of 20 ft.

Power, control and video cables were cumbersome and rather makeshift. They were selected from the most readily available GFE stock which would meet general requirements. During one test the video cable (RG-41/U) parted from strain induced while moving the camera unit. All cable lines should be contained in a common sheath of minimum overall size and weight.

Recommendation. Television can be an effective aid to underwater investigations providing certain design requirements are incorporated. Some of those immediately obvious from the results of these tests are as follows:

A. If designed for use by divers, camera units and connecting cables must be of such size and weight that one man can maneuver them readily. Weight of the camera in water should not exceed five pounds.

B. Cameras should be equipped with wide-angle lenses.

C. Greater depth of focus is desirable.

D. If increased camera sensitivity could be obtained, (a) the lens aperture could be stopped down, thus giving greater depth of focus, and (b) vision at lower light levels would be possible.

E. Accurate stabilization of electrical focusing controls is desirable, to minimize need for readjustment, and to prevent drift of focusing potentials.

F. A shutter should be provided to protect the orthicon pick-up tube against damage from excessive illumination when not in use. On one occasion during tests, the photocathode screen was spotted from direct sunlight while lowering the camera unit into the water.

G. Design of watertight camera cases should be easily accessible for installation or removal of cameras. Connecting cables should be mechanically protected at points of exit from the cases..

H. Basic investigation of various illuminating techniques should be accomplished.

I. Techniques for photographing the television image must be perfected in order that photographic records will equal the detail of the television presentation.

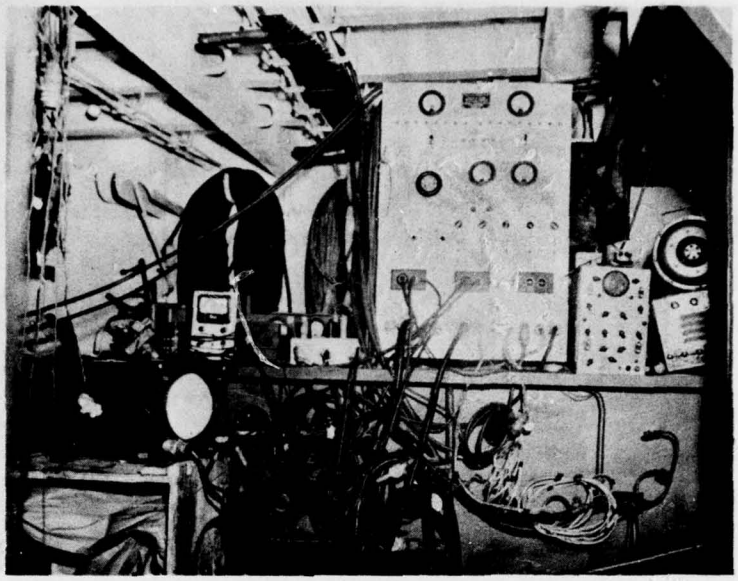

Figure 19. TELEVISION. Control panel, screen and diving telephone to diving booths aboard COUCAL. ABCR Photo No. 5082-8.

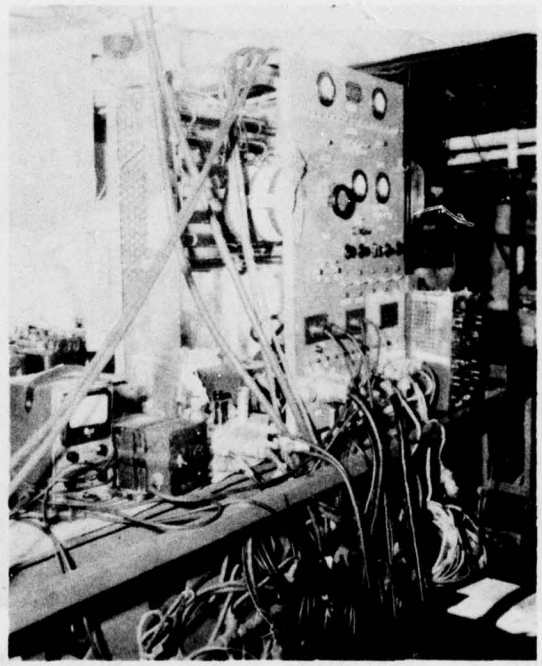

Figure 20. TELEVISION. Control panel. ABCR Photo No. 5082-11.

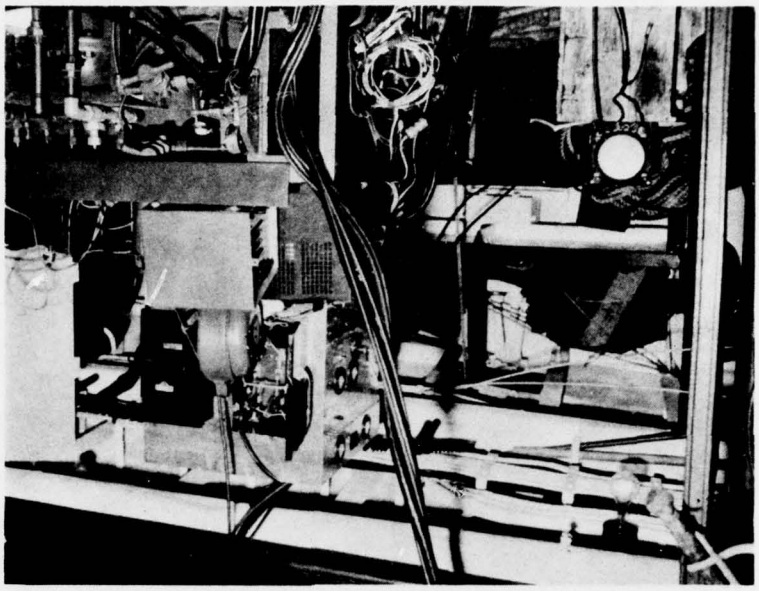

Figure 21. TELEVISION. Television equipment installed on COUCAL showing screen, control panel and diving communications gear. ABCR Photo No. 5082-9.

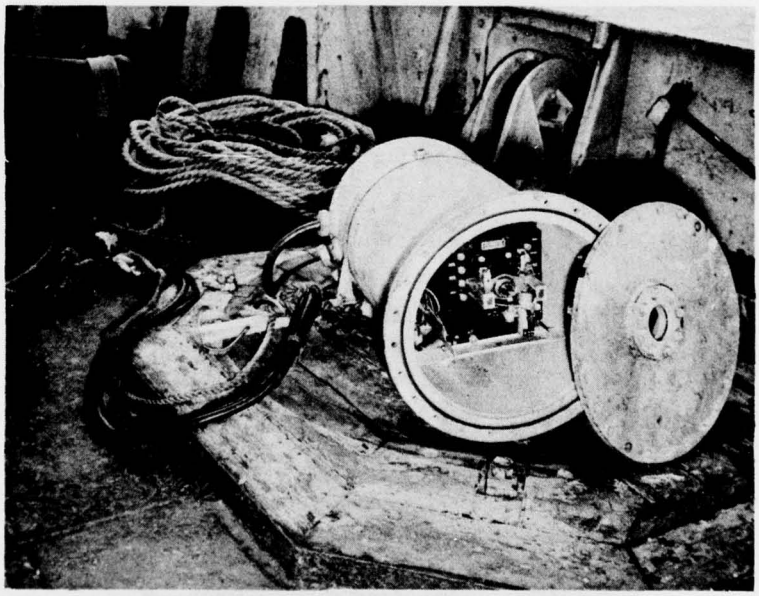

Figure 22. TELEVISION. Camera in water tight, steel case. Note cables at left. ABCR Photo No. 5082-7.

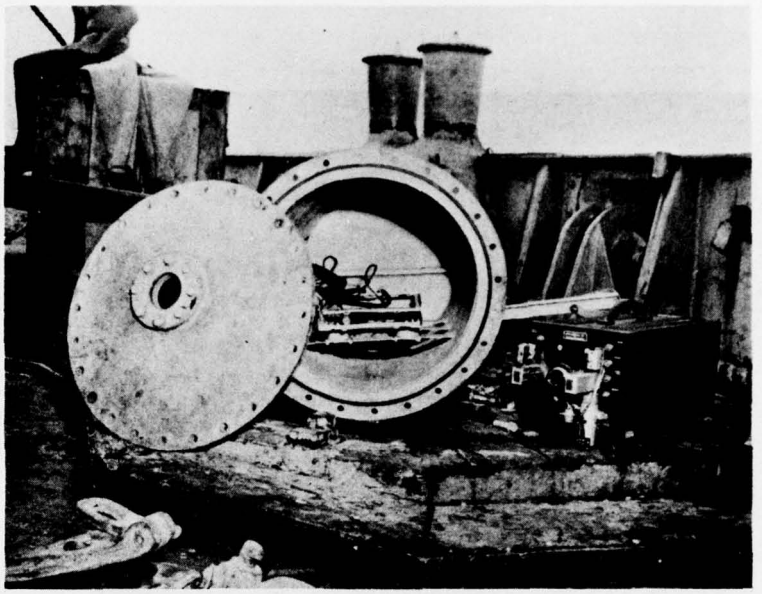

Figure 23. TELEVISION. Camera and water tight, steel case showing shock mountings inside. ABCR Photo No. 5082-5.

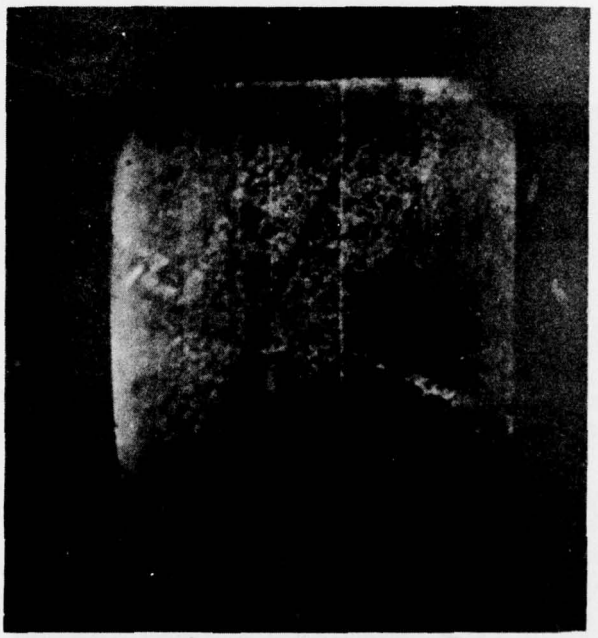

Figure 24. TELEVISION. Starboard catapult and securing track in flight deck of SARATOGA. ABCR Photo No. 5109-11.

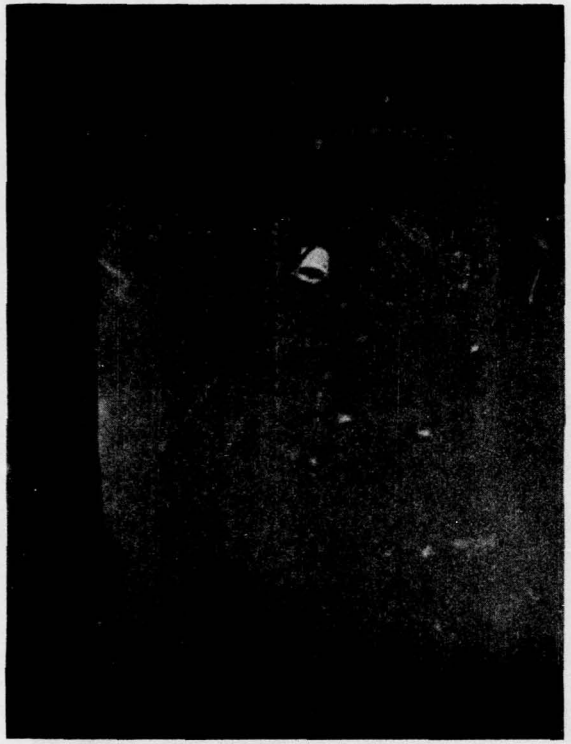

Figure 25. TELEVISION. Securing track on flight deck of SARATOGA. ABCR Photo No. 5109-8.

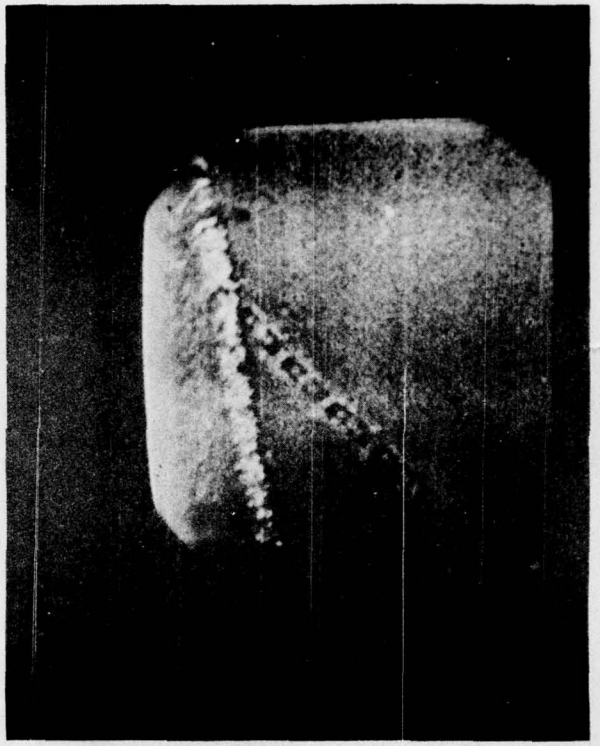

Figure 26. TELEVISION. Securing track on flight deck of SARATOGA showing radio antenna bent across deck to port. ABCR Photo No. 5106-12.

Figure 27. TELEVISION. Diver on flight deck of SARATOGA. ABCR Photo No. 5106-8.

Figure 28. TELEVISION. Diver on flight deck of SARATOGA. ABCR Photo No. 5106-4.

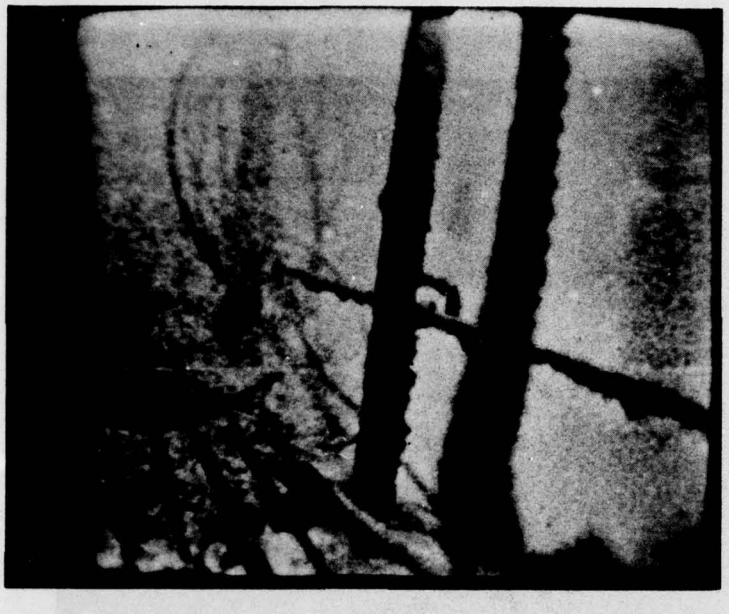

Figure 29. TELEVISION. Deck along conning tower of APOGON. ABCR Photo No. 5082-4.

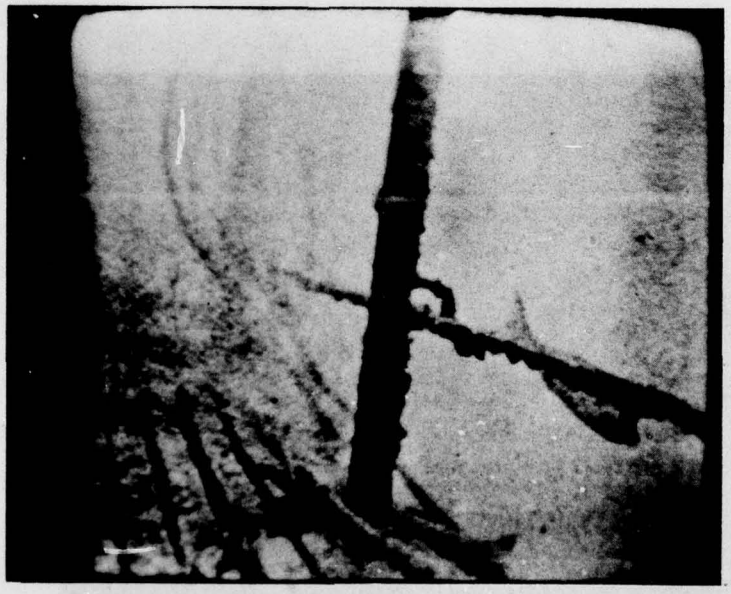

Figure 30. TELEVISION. Deck along conning tower of APOGON. ABCR 5082-3.

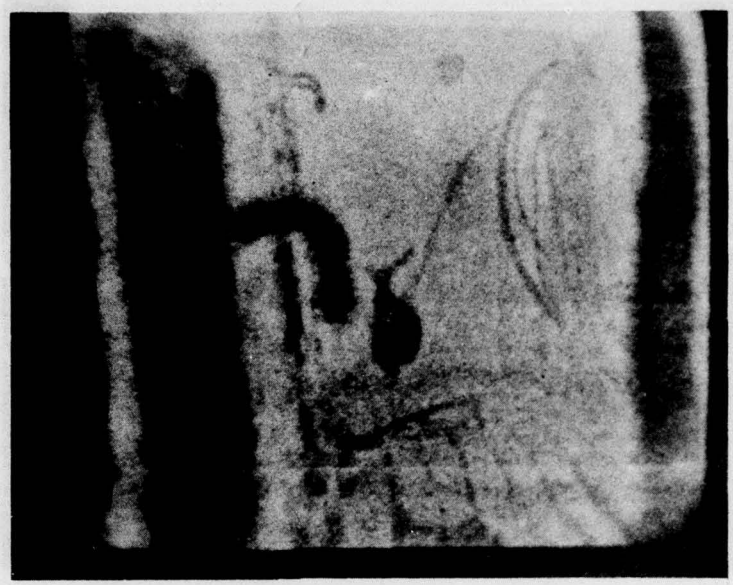

Figure 31. TELEVISION. Deck by conning tower on APOGON. ABCR Photo No. 5081-12.

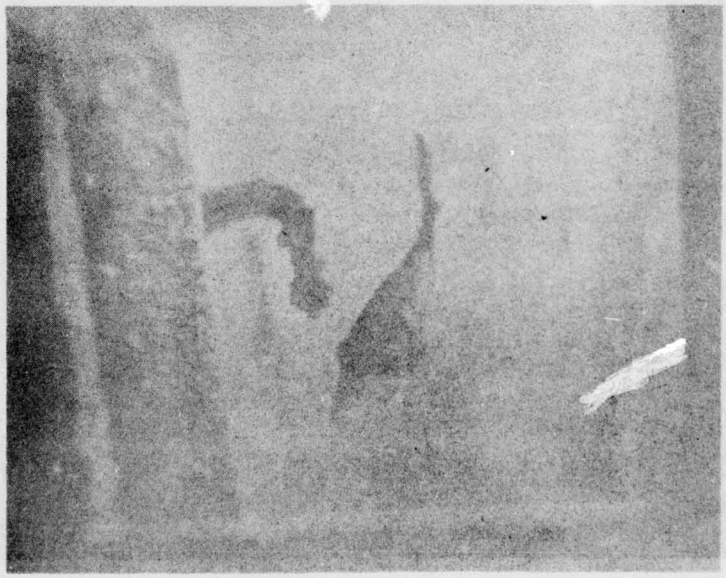

Figure 32. TELEVISION. Deck along conning tower of APOGON. ABCR Photo No. 5081-10.

Figure 33. TELEVISION. Deck along conning tower APOGON. ABCR Photo No. 5081-9.

Figure 34. TELEVISION. Deck of APOGON by conning tower. ABCR Photo No. 5081-6.